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A STRATEGIC SCENARIO PLANNING TO EMBOLDEN BEVs VIABILITY FROM A CAR MANUFACTURER PERSPECTIVE

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Abstract

The automotive industry is on the eve of disruption, and the ongoing industry macro forces are paving the way for the rebirth of electric mobility. This rears the doubt of whether traditional automakers are up to the challenge of adapting to the electric developments. In this perspective, the author examined a set of inhibitors and drivers impacting the decision of adopting an Electric vehicle (EV) and compares the profitability of manufacturing a BEV explicitly to a traditional car. In this perspective, by gathering the macro analysis to author's industry expertise, a strategic plan was constructed assuming several future scenarios to recommend how manufacturers should react and adjust to possible situations, and survive to the change.

Keywords: Electric vehicles, manufacturing, cars, strategy, cost, adoption, analysis

1. Introduction

Digitalization is the root cause of today's transformation of industries, and the car industry is no exception. Considering the technological upsurge and social-environmental concern as atmospheric destruction and health issues arise from urban pollution (Andwari et al. 2017), expectations are building about the future of the industry coming from several stakeholders. It becomes, therefore, an urgency for carmakers to strategize over an uncertain future, considering electric vehicles (EVs) as the next step for mobility. Models thought over-priced comparing with traditional alternatives were released so far (Andwari et al. 2017), concerns over natural resource availability, especially lithium (Speirs et al., 2014), governmental and consumer acceptance (Klamor et al., 2015) all pose particular challenges for an uncertain future.

This dissertation will be developed from a car manufacturer perspective, as they are a central player in the market by shaping innovation, which will ensure not only their long-term profitability (Eveleens, 2010) but also their impacting the mobility world. This work aims, therefore, to provide a strategic overview and possible strategic actions for automakers in the EV market. Deriving out of my current participation and background in the auto industry, specifically in a company devoted to the development of technologies related to EVs, the scope of the study motivated me to delve into the electric mobility world. This way, this thesis is accomplished by consolidating real work experience with literature in the automotive sector.

2. Literature Review

1828 - 1835. The first attempts and prototypes of electric vehicles were presented to the world. Evidence coming from Hungary, Netherlands, and the USA shows that this idea is not a modern time finding (U.S. Department of Energy, 2015). An extensive research on known academic search engines and retrieving to as far as results from 1850 shows that academia was aware, and was working on the topic. In an article from 1997, it is stated that "The electric vehicle has been viewed as a technological solution to the dual plagues of dwindling fossil fuel supplies and pollutant emissions from gasoline-powered vehicles" (Buca & Brausen, 1997). But on the other hand, literature states that consumers tend to be price-sensitive and to only raise awareness for those problems after driving an EV and receiving the necessary information (Dudenhöffer, 2013). So, the lack of information and contact with the technology were pointed as causes for the lack of adoption and failure of electric vehicles.

In 2019 information was widespread and available, and so are EVs. The car industry is facing exponential change, and automakers need to adapt fast to answer customer demands. Since information is crucial and considering that this analysis was conducted from a perspective within the car producers, most of the information presented was based on actual up-to-date reports coming from automakers, suppliers, and governments.

Industry and Market

The metamorphosis over various industries due to the digitalization wave is reshaping business models worldwide, releasing space for new value creation along with a handful of risks. Driven by social, technological, and industry forces, the automotive industry is facing an unparalleled revolution that is changing the face of mobility. This section provides a macro overview of the state and perspective of the challenging car industry and market.

Employment

The automotive industry is one of the powerful engines driving the world economy. In mature economies, auto industry employment is an indicator of manufacturing sector health, and in many developing countries, expanding and prospering a local vehicle represents a priority of industry policy (Kenney & Florida, 2004). Solely in the EU, the automotive industry, including manufacturing, services, and construction, provided 13.8 million jobs, around 6.1% of the total employment (ACEA, 2019). In the past decades, automakers attained about 20% productivity improvements by automating and outsourcing white-collar jobs. Consequently, a reduction in the workforce could be expected, causing a significant recalibration in the type of tasks performed, notably better analytics skills will be needed company-wide (Kelp et al., 2018).

Sales & Production

Over the last decade, the industry experienced a boost in global vehicle sales. From almost 75 million in 2010 to 95 Million units in 2018, the sector reached a growth of 21% over the last eight years. Despite these numbers, in 2018, the global vehicle sales have broken the growth of the past years, with total sales of around 95 million units, 0.7% lower than in the previous year. Asia (also includes Oceania/middle east), accountable for 50% of the total sales in 2018, has been the focal engine for growth over the past years. Regardless, Asia was the only region experiencing a reduction in unit sales as compared to 2017, approximately 2% less. Whereas Europe's vehicle sales remained flat compared to 2017, the American region increased by 1%

in 2018, which follows a decrease of 0.4% in 2017. In the same period, Africa recovered from a reduction of 15.6% in 2017, with an increase of 8% in 2018 (OICA, 2018).

Global production, during the past eight years, experienced a significant enlargement. Nevertheless, in 2018, the total global production was 95.7 million units, representing a decrease of 1% from 2017, around 1 million units. American vehicle production persisted smooth as compared to the reduction experienced in the region in 2017. However, economic uncertainty and increased market volatility imposed a different reality for the rest of the world. Asia, 54.8% market share, and Europe, 22.3%, experienced decreases in vehicle production of 2% and 1%, respectively. Africa accounted for 1.2% of the global output, accomplishing an increase of 12% in vehicle production (Aptiv, 2018) (OICA, 2018).

Players

The automotive supply chain comprises all activities which indirectly or directly are incorporated in the transformation flow of a vehicle (Ahi & Searcy, 2013). Auto industry supply chain ranges from producers of raw materials up to the assembly of complex electronic and computing technologies to the end-user (Tang & Qian, 2007). Based on a modular production systems process, the supply chain is composed by subassemblies of the vehicle before the final assembly stage, generally including suppliers (tier 1 to 3), automakers, distribution centers, dealers, and consumers (Camuffo, 2004). Automakers purchase complete subassemblies, such as doors, power trains, and electronics from tier 1 suppliers. Tier 2 and 3 source the raw materials and produce sub-components to Tier 1 (Braese, 2005). Nearly all automakers produce 30 to 35% of value in-house and assign the rest to their suppliers (Ambe et al., 2010). The automakers regularly market the vehicles, complete the final assembly of components, and typically ship it to distributors via rail (Braese, 2005). Dealers receive the cars from the manufacturing plant, or vehicle distribution center and create revenue from the sale of new cars, used cars and service parts to consumers (Braese, 2005).

Suppliers

By being manufacturers of auto components, both automakers and suppliers carry similar business models, key performance indicators (KPIs), revenues and profit drivers (BoA, 2017). Demand in the auto industry is widely a function of the volume of vehicles produced in reply to customer demand. Furthermore, the market is cyclical and fundamentally driven by macro factors, such as driving age population growth, consumer confidence, growth in disposable income, employment trends, interest rates, and the price of crude oil (Aptiv, 2018). As macro factors suffer variations, demand consequently changes, influencing production directly for suppliers, decreasing their revenue. The reduction in supplies' production affects automakers, either by an increase in the component cost, altering the overall value of the car or by decreasing the supply, diminishing their revenue. As such, production volumes act as an industry KPI.

Ranked by sales of original equipment components, in 2018, Bosh Group was the leading global supplier with automotive revenue of around 49.5 million dollars, followed by Denso Corp, Magna International Inc., Continental, and ZF Friedrichshafen, with respectively 42.8 million, 40.8 million, 37.8 million and 36.9 million (Chappell, 2018).

Automakers

Ranked by sales, Volkswagen Group is the leading motor vehicle manufacturer worldwide with around 10.8 Billion units, followed by Renault – Nissan and Toyota with a bit more than 10 Billion each. In terms of revenue, Toyota, owned by Toyota Motor Corp., is taking the lead with a market share of 9.46%, followed by Volkswagen, Ford, and Nissan with respectively, 7.38%, 5.83% and 5.42% (Statista, 2018).

Intensifying competition and rigorous emission targets require automakers to launch models, including new features, especially in terms of connectivity, electrification, and autonomous driving, impacting their Capex and R&D expenses. Based on 2017 and 2018 statistics, about 10% to 11% of automotive revenues (excluding Tesla with around 50%) were captivate by R&D and CAPEX. Notably, in 2017, Volvo car and VW stood out with respectively 16% and 14% of R&D and CAPEX as a percentage of automotive revenue. In divergence, PSA, Toyota, and Nissan presented an under average rate of 8% each. The projected data for 2019-20 shows no significant margin to curtails for automakers (S&P Global, 2018). It is estimated a reduction in revenue growth over 2019-20, of around 1%. Additionally, over 2019-20 adjusted EBITDA margins are predicted to be approximately 10%, mostly supported by ongoing cost reductions measures, originated primarily from optimization of the mix (S&P Global, 2018).

Electric Mobility

The OECD estimates that over 70% of the advanced world population lives in urban areas. Thereby, people are being affected by the high level of air pollutants coming out of road transport, particularly from conventional vehicles (Stević, 2012). Although the upcoming EVs' future remains to be written, greener vehicles are vital to lessen the damage in the environment. To stimulate the world's transition to sustainable transport, decarbonization of cars - vehicles moving without releasing polluted gases from the tailpipe - is mandatory.

An EV is an alternative automobile that, instead of using conventional methods, like an internal combustion engine (ICE), uses electric motor and motor controllers (Palinski, 2017). Classed by the degree of electricity used as a power source, there exist three main types of Electric Vehicles: battery electric (BEV), plug-in hybrid electric (PHEVs), and hybrid electric (HEV). BEVs, solely powered by electricity, contain rechargeable high capacity batteries packs that store electricity onboard, used to run all electronics of the car, and the electric motor. Once depleted, the battery has to be plugged into the electric power grid, external source (Palinski, 2017). The PHEVs and HEVs are made of two engines, power-driven by electricity and alternative fuels. In this case, an internal computer controls the two motors, ensuring the best economy for the driving, operating at maximum efficiency (EVgo, 2019).

Vehicle sales play a crucial role in the early development of the EV market, through creating economic efficiencies in production and building scale (Gyimesi & Viswanathan, 2011). The year of 2018 accounted for an increase of EV global sales, compared to 2017. China presented the most considerable increase in sales, with 78% increase as compared to 2017. (EEI, 2019. At the same time as the share of EVs on the road increases, consumers are more likely to become familiarized and possibly consider their next purchase (Gyimesi & Viswanathan, 2018).

In 2018, BEVs accounted for approximately 66% of the total stock of electric passenger cars, around 3.3 million vehicles, an increase of about 69% in comparison to the previous year. In China, a total of 1.77 million electric passenger cars were on the road, about 54% of the total fleet. In comparison, the USA accounted for 22% of the global BEV fleet and Europe for 19% (IEA, 2019).

Drivers

I. Government Regulations

As a result of the ongoing population growth, global mobility and urbanization, the demand for fuels for transportation has amplified over the last decades (Creutzig et al.,2014).
Global warming is indicated by a rise in the average temperature of the earth´s surface over the past decades, and greenhouse gases (GHG), specifically Carbon Dioxide (CO2), which is considered to be responsible for the recorded climate change (NASA, 2011). The annual footmark of the auto industry, equivalent to 9% of the global annual GHG emission in 2018, is a result of emissions during the production, usage life, and end of life of a vehicle (Stephan et

al., 2018). During its lifetime, based on an average VW group vehicle, a car produces around 44t CO_2 emissions, whereas the production stage accounts for 6.8t CO_2, the usage stage for 34.5t CO_2, and 2.7t CO_2 e is related to end of the life (Stephan et al., 2018) (see appendix 1).

By examining the root cause of emissions in the usage phase, it was concluded that fossil fuel consumption was the cause of approximately 66% of the lifetime emissions of the vehicle (Stephan et al. 2018). To reverse the situation, it is required to strengthen government regulations, and for those measures to have a substantial impact, it is essential international adoption of best practices (Ripetskiy et al., 2018).

EV fostering, along with decarbonization of power systems, represents a significant aid for the environment. Thus, the government's purpose shall be to grow up the availability of vehicles with low and/or zero tailpipe emissions, diminishing in that way the fossil fuel dependency — every government emissions requirement act as an immediate catalyst for EVs (IEA, 2019).

II. Subsidies and Other Incentives

Consumers are unlikely to pay a premium price for social benefits that would not directly benefit themselves in the short time. Hence, governments worldwide attempt to encourage the demand for EVs through direct subsidies and fiscal incentives to consumers and businesses (Bakker et al., 2013). Explicitly, at the market promotion stage, EVs' mass adoption depends on government support (Mock, 2014). Direct subsidies concern a one-time investment or bonus, and the fiscal incentives refer to the tax exemptions or credits. Depending on the market, financial incentives aim to target consumers and manufacturers. In respect of consumers, incentives, such as tax credits, reductions, exemptions, or direct subsidies, are used to convince that EVs are not only environmentally-friendly but additionally cost-effective. Regarding manufacturers, incentives, such as reduction of the sales tax depending on CO_2 emission level and subsidies for the production of EVs, aiming an increase in EVs quantity and quality.

Although literature slightly diverges on the impact of financial incentives on the new vehicle technology adoption, the majority demonstrates as positively influence on consumer adoption intentions (Sang et al., 2015).

III. Fuel Cost

The most significant variable influencing the core price composition of oil is the crude oil cost, generally supplied by the OPEC (Palinski, 2017). Due to the consumers' low elasticity of demand for gasoline, oscillations in fuel prices tend to influence the marginal propensity to consume (Gelman et al., 2017).

In the last decade, global fossil fuel prices have been suffering extreme deviations (Shafiee & Topal, 2010). In 2018 (appendix 2), the global gasoline, diesel, and crude oil average price was $0,94, $1.05, and $0,45, respectively. Therefore, representing an annual increase of around 14% for gasoline and diesel, and 32% for crude oil, comparing to 2017. The same pattern is noted in the comparison between 2016-17, with increases of around 26% for gasoline, and 8% for diesel and crude oil (IEA, 2019). Even though it is hard to forecast energy prices due to market volatility, it is expected for 2020 similar increases, due to a mismatch between production and demand, and as the world depleted existing resources (Marcus, 2019). Escalation in fuel prices and progress in the alternative energy industry has led the economic environment to be more appropriate for EV deployment.

IV. Consumer awareness

One of the most dominant environmental concerns in the 21st century is environmental pollution and its impacts on human health, global warming, and ozone layer depletion (Nunes & Bennett, 2008). The growing call for the green concept is driven by increasing consumer awareness, ergo affecting the adoption intentions directly (Lai et al., 2015). People are concerned about the climate and desire to make a positive contribution to the generations to come (Musonera & Cagle, 2019). By exercising their power in their daily life decisions and pushing companies to be sustainable, consumers aim to reduce their harmful influence on the environment. Thus, according to the World Resource Institute, the eco-friend trend may have a massive impact on several business (Nunes & Bennett, 2008), including on mobility.

Barriers

I. Limited product availability

Typically, in the past, automakers used to perceive EVs as a conformity car. For that reason, based on a market analysis conducted regarding the number of BEVs available (detailed information on appendix 3), the number of batteries BEVs models available today on the market is still modest, encompassing around 34 models shared among distinct segments. For instance, the SUV segment presents the largest share of models, about 12%, followed by medium, small, MPV, large, executive, and mini segments, with 18%, 15%, 12%, 9%, 9%, and 6%, respectively. The year 2019 is pointed as a transitional year, and as of 2020, the offer will increase by about 30 models yearly, mostly SUV segments. Overall, as a consequence of CO2 emission standards, it is predicted that in the coming years, 78 models will be available to consumers in all segments, including luxury. At that point, estimations predicted that SUV would continue to be the segment with the largest share of models. Despite the estimates of evolution, EVs still embody a small percentage of automobiles, compared to traditional vehicles. The short offer represents a disadvantage, in the eyes of the consumer, leading to some hesitation when obtaining a car. Besides feeling restricted to the limited number of models available, the price related to those models aggravates the situation by driving consumers away from choosing EVs as an alternative.

II. Charging Infrastructures & Driving Range

The primary requirement, when someone possesses a car, is to have the possibility to charge it easily (Palinski, 2017). For instance, charging time and limited infrastructure to do so, constitute barriers discussed in the international literature. Although 95% of vehicles' batteries are charged during the night, not all people have the opportunity to do it (Boxwell, 2016), (Erjavec, 2012). The difficulty takes place when one charge range is not enough for the outlined trip, forcing consumers to plan their journey based on the charging points grid (Palinski, 2017). Seemingly, creating the charging infrastructures needed for large-scale EV requires a relevant undertaking to spread EV adoption. Otherwise, the lack of access to a well-organized refueling infrastructure works as a roadblock. Unlike traditional vehicles, commonly refuel at gasoline stations, EVs can be recharge in multiples ways, depending on the category. Currently, concerning battery charging, there are three charging methods (Gyimesi, 2011). Level 1, with the capacity to charge the majority of EVs available in the market, is primarily used at home and office since no supplementary infrastructure is needed. This method enables to recharge the vehicle overnight and take advantage of low-cost night rate power (Veneri et al., 2012). By plugging into a 120-volt, it is projected to be only an entry-level in the introduction of BEVs, providing a small amount of energy, consequently prolonging charging time (Gyimesi, 2011). Level 2, typically found in urban areas, is completed by plugin to a 240-volt circuit and requires specialized equipment, such as a wall or pedestal mounted equipment (Gyimesi, 2011). Level 3, also denominated ultra-fast charging DC, involves large and high specialized stations, as well as high powered equipment in the vehicle itself. Currently, only a few cars can support this charging method due to its high voltage (Gyimesi, 2011). Simultaneously, in contrast to ICEs, EVs can be recharged by a process named regenerative braking, which extends the driving range (Xu et al., 2011).

The achievable distance a vehicle can travel on a full tank is recognized as one of the biggest inhibitors to the adoption of BEVs (Bonges III & Lusk, 2016). Even though BEV's driving range is satisfactory for most trips, it is still surpassed by a variety of ICE vehicle. This fact is compelling drivers to plan their trips cautiously and earlier, provoking fear and anxiety of being left stranded during road trips. Due to the limited range autonomy, and inadequate infrastructures available, BEVs tend to fit perfectly in urban transport commuting trips.

III. Purchasing price

A comparative analysis conducted on the available data exposes BEVs as being on average, and considering the average transaction price on every segment all around, more expensive than ICE vehicles, by about 5% of the purchasing price (EVAdoption, 2019), (Kelly Blue Book, 2018). In coincidence with this data, it is mentioned in the literature on the topic that prices will play an essential role in the uptake of BEVs, as it might be considered the most significant market barrier to consumers worldwide (New Zealand Government, 2018). The literature makes as well reference to the importance of incentives for the adoption of such vehicles (Yang et al., 2015). The fact that price appears as a barrier for consumption may, in turn, compromise the sales, and consequently, the revenue of automakers.

IV. Manufacturing Costs

As the industry progress through the transition to fully electric powertrains, automakers must balance a complex set of challenges that affect all aspects of the business (Mosquet et al., 2018). It is anticipated substantial obstacles to profitability and expansion of competitive landscape diversity in the medium-long term (Mosquet et al., 2018).

To assess current manufacturing costs, I followed an analysis conducted by the Bank of America (see appendix 4). In that way, it was possible to understand how, when, and if BEVs will reach the profitability attained. The analysis compared the production cost of both types of cars based on their cost per component, excluding final assembly, marketing, and overhead cost. Thus, both ICE and BEV were decomposed into different components systems, covering its main functional areas. Additionally, to assume similar margins on an ICE vehicle in comparison to a BEV, the component cost of an ICE vehicle was grossed up in line with revenue per unit.

The overall estimated cost of an average ICE vehicle was determined to be 21.760 USD. The most substantial element, in terms of price, was the engine, with a value of 4.013 USD, representing about 18% of the car's total cost. At the same time, the study determined that the appraised cost of a BEV was approximately 33.600 USD, where the costliest component was the battery cell, with a value of 11.460 USD, about 34% of the car's production cost. Direct assessment between the ICE vehicle and the BEV component structure denoted that in the BEVs' composition, four components were excluded: the exhaust, fuel system, transmission, and engine, translated in a cost loss of approximately 7.088 USD. However, the EV electrical architecture, electric motor, power electronics, and battery cell were added, summing a total extra cost of around 16.875 USD. To sum up, BEV presents an overall additional production cost of about 9.788 USD, in comparison to the total manufacturing cost of a traditional vehicle. Therefore, as the trend expands, it is likely that the individual cost per component reduces gradually as a consequence of production processes improvements and technology developments.

V. Battery cost

The battery is critical in a BEV, as it is the only energy source. And still, it is the part with the highest cost, weight, and volume. There exists a concern within the industry about the need for battery cells capable of electrifying the “long-range, low-cost, and high utilization transportation sectors” comparing to the ones being used today in the majority of the BEVs. (Cano et al., 2018).

Lithium-ion batteries (LIBs) are nowadays the most used energy storage equipment for powering EVs (Stević, 2012). Although a valid option, as it offers high energy density capacity in comparison with other rechargeable batteries, LIBs' cost is still considered a handicap (Andwari, 2017). To reduce BEVs cost, automakers instituted an imperative of reducing the cost of the battery pack. The battery pack is composed of cells, considered the most cost-intensive part, representing approximately 70% of the total cost of the pack (Kupper, 2018).

A key concern regarding the cost of the battery is the main component being used in its construction: Lithium. Even though several alternatives are being developed, in order to try to enhance the range or durability, lithium is still being used as a main component, as we can see in the examples of Lithium-Argon or Lithium-Sulfur battery cells. (Cano et al. 2018). While still uncertain, it is many times forecasted that the lithium demand for battery application might exceed the supply between 2020 and 2050, as there is no clear assessment on how easy to access this resource is, and it´s production timescale (Speirs et al., 2014).

3. Methodology

The study presented was constructed with the ambition of analyzing the electric vehicle market from a car manufacturer's point of view and, therefore, analyzing the likely future outcomes based on a combination matrix of possible scenarios.

To understand the actual state of the car manufacturing industry, and to select relevant work built on the topic, to be used as the theoretic basis sustaining the strategic analysis, I started by completing a preliminary research on the available scientific databases provided by Nova School of Business and Economics searching topics such as "Electric vehicles," "Car industry," "Future of the Car Industry" and "Electric Vehicle vs. Internal Combustion Engine Vehicles.". A set of 52 papers were gathered based on their title and consonance with the searched keywords. After analyzing their abstract, I decided to exclude the ones focusing on an industry analysis from a consumer perspective as they do not provide relevant information for the present work. In consequence, I was apt to congregate material pertinent to implement a macro analysis based on the industry and market trends. By combining the macro analysis with a set of reports collected from auto players, national governments, and individual researchers, I then proceed to organize the data into collections of drivers and barriers for the acceptance of EVs in the auto market. Subsequently, after evaluating the outcome of each variable, I then extended the analysis by selecting two major influencing factors.

When considering the uncertainty car industry faces in the near years, there are many tools automakers can use in order to plan strategically. Scenario plan, however, has the ability to capture a wide spectrum of possibilities (Schoemaker, 1995) and therefore allowing managers to plan a more complete set of actions for the future to come. I decided to use this methodology as it allows not only to have a look into the most seemingly obvious outcome, but as well into the unpredictable possibilities where competitive advantage might reside (Schoemaker, 1995). I understand as well the importance of not losing the scope, and therefore decided to work within four different hypotheses (Godet, 2000) in order to formulate, considering of course all the macro factors as constants in our analysis.

4. Strategic Planning

To track the disruptive trend and adjust towards fitting in a new world of automobiles, automakers must look ahead, antedating transformation, and developing strategies to proactively navigate through the disorder originated by change. In that manner, by developing strategic analysis, assuming likely future scenarios, automakers can apply possible actions to challenge the status quo (see Figure 1). Following the study of the large-scale drivers and barriers and adjoining my background on the industry, two variables stood out for their unswerving impact on automakers: environmental government regulations, and battery cost.

Pursuing competitive advantage over developing countries that play a significant role in the car industry, through socio-economic and strategic models, governments have an essential role in promoting frameworks that facilitate the evolution of EVs (Hildermeier & Villareal, 2011). As an example, we might look at the European reality, where the European Commission's policies-European Green Car initiative and CO2 emission regulations (Hildermeier & Villareal, 2011) combined with local tax incentives (Situ, 2009) will make the adoption of EVs a "fatality." It remains, however, the uncertainty of future policies (as well as energetic concerns) that will determine the speed with which this vehicle will be adopted.

In this scenario analysis, regarding environmental government regulations, two extremes were considered: extreme and moderate. In the extreme regulations side, it was studied the possibility where governments play an active role by obliging automakers to devote 100% of vehicle production to EVs. On the other hand, in moderate regulations, the government has a passive approach, demanding lower quotes of EV production, leaving the decisions for the market forces.

Additionally, battery cost was selected as the second variable in this analysis, as it is now the main cost for automakers as of components to be built into a BEV and therefore demands more consideration from a strategic and decision point of view. Batteries are seen as essential for the strategic analysis as it represents a set of uncertainties that will ultimately impact the market and the strategies of automakers as: the concern with the energy production source, the availability of resources such as lithium, and the evolution of the battery cost-wise within the product-life-cycle. Therefore, concerning battery cost, two extremes were selected: restrictive and non-restrictive. Ultimately, I decided to choose these two axes, as they prove to be essential for the development of every possible strategic scenario. It is important to disclaim that since this is a scenario analysis is based on hypothesis, everything else in between is also a possibility.

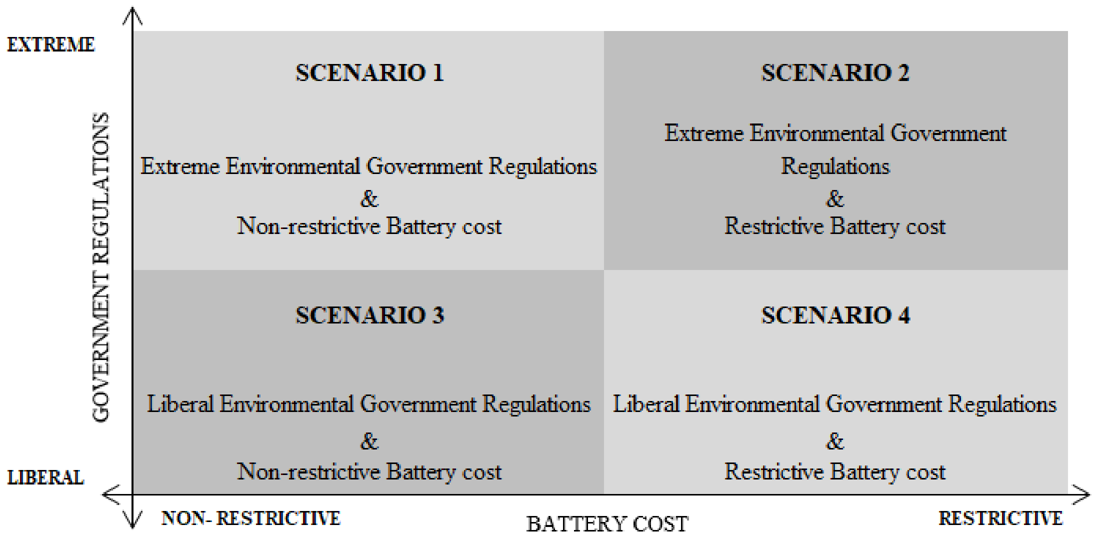

Figure 1: Scenario Planning Matrix

SCENARIO 1 - Extreme Government Regulation & Non-restrictive Battery cost

Automakers would become capable of attaining an acceptable manufacturing cost, comparing to ICE vehicles, not being hampered by regulations. The extreme environmental regulations would limit the share of traditional cars on the road, reinforcing the trend. Together, the two forces would likely curtail the EVs' purchasing price, and enhance producers' profit margin, boosting consumer and producer adoption.

Strategies to be implemented

I. Extend the product availability: In today's competitive environment, audience segments must be identified and targeted accordingly; otherwise, they may be won by the competition. In the way of creating competitive advantages, automakers must comprise a complete portfolio of products. By developing an active core product line, while offering a depth product mix, adequate in size, color, and functionalities, automakers could appeal to an ample length of potential customers, benefitting from scale and learning economies, by using the same workforce skills and production lines. In such a way, auto players could not only intensify the variety of models in the market, as differentiate themselves from the competitor by investing in perks that add value for consumers, such as new car features.

II. Extend the scope of activities: As cost is not a restriction, and governmental regulations are fixed, automakers should, while still participating in the BEVs commercialization, focus on problems that might affect the sustainability of the market. As energy supply might suffer from an accelerated demand, since regulators will impose a 100% electric policy, the energy source will now become the most significant environmental concern. Having electrical energy produced from fossil fuels will still be a burden for consumers when adopting a supposedly "greener" alternative. Automakers should invest in promoting accessibility to environmentally friendly electric energy, acting, for example, through partnerships with typical energy providers to accelerate the development process or as a market facilitator.

SCENARIO 2 - Extreme Government Regulation & Restrictive Battery cost

By government regulations, the share of ICE vehicles produced by automakers would become null even though their cost of manufacturing, due primarily to the battery cost was lower in comparison to EVs. Thus, consumers would experience inflation in the short term on vehicle prices, pushing them away from embracing the EV, consequently reducing the sales volume. Forced to produce EVs, automakers would be required to shift their strategies and look for other ways to become profitable.

Strategies to be implemented

I. Mobility as a Service (MaaS): Forced to live in a world where regulations have a significant impact and battery cost influence the production cost, it is likely that automakers, to achieve the same profit margins as with traditional vehicles, would increase EV's sale price. Therefore, consumers' low elasticity of demand would be reflected in their purchasing decisions, encouraging them to search for economic alternatives. In that way, it is suggested that automakers would have to embody a user-centric perspective and invest in parallel trends in the auto industry, namely mobility as a service. Powered by urban density growth and growing embracement of people for new mobility services options and apps, MaaS would deliver an alternative to private vehicles trips, and ultimately to vehicle ownership. Since governments play a necessary part in the safeguard of the transportation environment by ensuring its safety and security, automakers could even attempt to settle agreements and grants with national entities to have assistance in the capital investments.

II. Strategic Alliances: Battery price and regulatory tensions restrain automakers when making the appropriate decision on how to differentiate. Although without knowing what will prevail in the future, automakers, to develop electric powertrains and survive to the possible scenario, must invest significantly in R&D. To overcome the burden of investments and improve core activities, and due to industry uncertainty, it is suggested that the industry could move towards greater co-operation. By creating strategic alliances, such as M&A or JV, automakers could not only share the cost but the business risk of the investment, as well as reducing ambiguities regarding unpredictable demand circumstances, that emerge from competitive interdependence. Additionally, due to difficulty in creating in-house advanced technology, as a result of high costs and need for specific skills, by join specialized expertise and knowledge, companies could achieve more easily learning economies spending less time and money, consequently driving down the cost.

SCENARIO 3 - <u>Liberal Government Regulations & non-restrictive Battery cost</u>

By having freedom to select the manufacturing mix to pursue, and considering that the cost of the battery does not restricts the automaker, it is expected that they will adapt to market demands. Given the growing environmental concern, especially in developed economies, the car will tend to follow its natural product life cycle, where a transition to the electric vehicles will occur in a gradual and sustained fashion.

Strategies to be implemented

I. Expand access to infrastructures network: Since ICE vehicles and EVs are available in the market for consumers and bearing in mind that the cost of the battery is no longer an inhibiting factor, it is suggested that automakers should devote their strategies to lessen other hurdles for EV adoption. Lowering barriers to charging infrastructure, by supporting a complete, easy, and affordable grid, especially in homes and workplaces, would boost the use of EVs across various modes of transportation. To overcome the ongoing random and isolated charging grid, automakers could strategically form alliances to encourage significant players in the infrastructure sector to keep working on infrastructure projects, creating an interconnected charging network based on market demands. In this case, automakers are not just trying to respond to external changes. They are shaping their future by developing the market.

II. Go green: Considering that both government regulations and production costs are non-restrictive, the automaker must keep track of the demand forces as the most significant industry market influencer. With "Go green" becoming a trend, especially in developed economies, I suggest that automakers should focus their production on EVs, seeking to benefit from gains in production efficiency and economies of scale. At the same time, this will allow the auto players to remove the pollutant label, improving air quality and people's health, and ensure a similar level of profitability to automakers, consequently comparable purchasing price for consumers.

SCENARIO 4 -<u>Liberal environmental government regulations & restrictive Battery Cost</u>

When the government tends not to impose market thresholds, and the cost of the battery is not representative from a production standpoint, carmakers will pursue the production strategy that provides the highest profit in the short term. As the battery cost is relatively high (possibly due to limitations in sourcing lithium), and that the environmental concern continues to rise as a macro trend from a demand point of view, automakers would have to adapt fast and consider alternatives.

Strategies to be implemented

I. Target premium segments: Since battery price is still restrictive, automakers will be powerless to produce and sell EVs at a price acceptable to all segments and classes of society. According to the Veblen effect, there are cases, commonly associated with luxury goods, where increasing prices can increase demand- and vice-versa. These abnormal market behaviors usually occur in the upper market segments, where the consumers are less price sensitive. According to this line of thinking, it is suggested that automakers could concentrate their production of EV solely to top market segments EVs, offering only premium options. Automakers should focus on providing high-quality products, including design elements, infotainment features, and safety and comfort, for a premium price.

II. R&D: Automakers shall invest heavily in R&D to find solutions that can be an environmentally friendly alternative to the electric car while still producing ICE vehicles, as they depend on the cash inflow to finance operational and investment activities, and as governments do not impose strict regulations. It is essential to state that the environmental concern is still present in the consumer mindset as it was previously stated, which could lead the consumer to search for alternative solutions such as shared mobility. Different base component for the battery (as hydrogen-based electric cells), or different mobility solutions would have to be considered by automakers to keep on selling cars.

5. Limitations and Future Research

Considering the study here presented and conducted, it is possible to identify a set of limitations which might, in turn, shed lights into possible future research: (1) the scenario analysis: the two variables selected were chosen based on their importance for the evolution of EVs, while other drivers and barriers had to be ignored. In a possible future research, other variables could as well be used in this type of analysis, allowing for a broader perspective on possible future outcomes; (2) the scenario analysis is mainly qualitative. In a future outlook on the topic, quantitative forecasts can be performed together with a broader set of automakers in order to obtain data as realistic as possible; (3) There is lack of an abundant literary source as up-do-date as needed when studying a topic based on such an exponentially growing technology. This led to either: Using data from previous years or using information sources, such as websites and company reports, which are not as academically valid as published papers but present up-to-date information on the industry. There exists, therefore, room for an increase in accuracy when perfuming further research on the topic, which can be obtained by having availability to a broader set of up-to-date databases.

As I understand the need for a strategic outlook on the future of such fast-paced industry, and since transformation brings with it a lot of social implications, such as the possibility of large sets of lay-offs, automakers should work together with researchers and governments in order to define a clearer path on the future of mobility, developing actions plans foreseeing the vast possibilities considering the impact if the industry in the global economy.

6. Conclusion

The electrification of the mobility industry is undoubtedly a huge challenge to be faced by automakers. And like all challenges faced in many sectors and this particular industry in the past, transformation encompasses drivers and barriers. I came to conclude that even though drivers, such as subsidies and other incentives, the influence of an increase in fuel costs and an increased consumer awareness regarding environmental impact, government regulations work as the biggest uptaker for the implementation of electric vehicles. When analyzing the market barriers, I concluded that given the high price sensitiveness, and as well given a comparison between the cost per component between the EVs and ICEs, the price of the battery represents the most significant burden for producers when trying to achieve sustainable profitability. By combining these two factors, and using a strategic scenario analysis to formulate possible hypothetical outcomes, I was able to develop strategic actions to be implemented by automakers. As I conducted this thesis, I came to understand that even though consumers take electrification as a guarantee, automakers still have a long path to pursue, given the exponentiality of the technology and uncontrollable barriers. It is, therefore, of significant importance for them to develop and analyze the market from a strategic and critical perspective, as there is a much broader set of possibilities than the four analyzed in this study. There is no GPS in this electrification path. And automakers must make sure there's enough gas in the tank to go all the way through (or battery).

REFERENCES

ACEA. (2019). "The automobile Industry Pocket Guide".

Ahi P., Searcy C. (2013). "A comparative literature analysis of definitions of green and sustainable supply chain management", Journal of Cleaner Production, 52, 329-341.

All things EVadoption. (2019).https://evadoption.com.

All things EVgo. (2019). Retrieved from https://www.evgo.com/why-evs/types-of-electric-vehicles/.

All things Kelley Blue Book Co. (2019). https://www.kbb.com.

All things NASA. (2011). Retrieved from https://scied.ucar.edu/longcontent/greenhouse-effect.

All things OICA. (2018). Retrieved from http://www.oica.net/.

All things Statista, (2018), Retrieved from https://www.statista.com/statistics/316786/global-market-share-of-the-leading-automakers/.

All things United States of America, Department of Energy (2015), Retrieved from https://www.energy.gov/timeline/timeline-history-electric-car.

Ambe, I. M., & Badenhorst-Weiss, J. A. (2010). "Strategic supply chain framework for the automotive industry". African Journal of Business Management, 4(10), 2110-2120.

Andwari, A., Pesiridis, A., Rajoo, S., Botas, R. & Esfahanian, V. (2017). "A review of Battery Electric Vehicle technology and readiness levels", Renewable and Sustainable Energy Reviews, 78, 414-430.

Aptiv. (2018). "Annual Report 2018".

Bakker S. and Trip J.J. (2013). "Policy options to support the adoption of electric vehicles in the urban environment", 25, 18-23.

Bank of America. (2017). "Global Automotive Supplier Review. Who Makes the Car- 2017".

Bonges III, H. A., Lusk, A. C. (2016). “Addressing electric vehicle (EV) sales and range anxiety through parking layout, policy and regulation”. Transportation Research Part A: Policy and Practice, 83, 63-73.

Boxwell, M. (2016). „The Electric Car Guide 2015 Edition”, UK: Greenstream Publishing Limited.

Braese, N. (2005). “The dynamics of supply chains in the automotive industry”, Massachusetts Institute of Technology, Engineering Systems Division.

Buca, P., Brausen, J. (1997). "The Electric Vehicle Market", Competitiveness Review, 7, 36-45.

Camuffo, A. (2004). “Rolling out a world car: globalization, outsourcing and modularity in the auto industry. Korean Journal of Political Economy”, 2(1), 183-224.

Cano, Z., Banham, D., Ye, S., Hintennach, A., Lu, J., Fowler, M., Chen, Z., (2018), “Batteries and fuel cells for emerging electric vehicle markets”, Nature Energy, 3, 279-289.

Chappell L. (2018). “North America, Europe and the world Top suppliers”, Crain Communications Inc.

Creutzig F., Dubeux C., Hupe J., Kobayashi S. (2014). “Energy End-Use: Transport”.

Dudenhöffer, K. (2013). “Why electric vehicles failed”, Management Control, 124, 24-95.

EEI, Edison Electric Institute, (2019). “Electric Vehicles Sales: Facts & Figures”, Customer Solutions, Pennsylvania.

Erjavec, J. (2012). “Hybrid, electric, and fuel-cell vehicles”. New York, Cengage Learning.

Eveleens, C. (2010). “Innovation management; A literature review of Innovation process models and their implications.”.

Ferraris V., Madlani N., Nakai K. (2018). “Industry Top Trends 2019. Autos.”, S&P Global.

Fournier J., Koske I., Wanner I., Zipperer V. (2013). “ The price of oil – will it start rising again?”, OECD Economics Department Working Papers, 1031.

Gelman M., Gorodnichenko Y., Kariv S., Koustas D., Shapiro M., Silverman D., Tadelis S. (2017). “The response of consumer spending to changes in gasoline prices”, National Bureau of economic research, 22969.

Godet, M. (2000) “The Art of Scenarios and Strategic Planning: Tools and Pitfalls”, Technological Forecasting and Social Change, 65, 3-22

Gyimesi K., Viswanathan R. (2011). “The shift to electric vehicles: Putting consumers in the driver’s seat”, IBM Global Business Services .

Hildermeier, J., & Villareal, A. (2011). “Shaping an emerging market for electric cars: How politics in France and Germany transform the European automotive industry”. European Review of Industrial Economics and Policy, 3.

IEA (2019), " World Energy Balances 2019 Overview", IEA, Paris.

IEA (2019), "Global EV Outlook 2019", IEA, Paris.

Kelp R., Miller A., Kaunitz B. (2018).“Building the automotive the automotive for the future-Tomorrow’s workforce will be lean and digitally adept”. Oliver Wyman.

Kenney M., Florida R. (2004). “Locating global advantage- industry dynamics in the international economy”, California, Standford University Press.

Klamor S., Diekmann J., Grützke M., Kraft V., Kwade A., Winter M. (2015). “Aging investigations of a lithium-ion battery, electrolyte from a field-tested hybrid electric vehicle.”, J Power Sources, 273, 83-88.

Kupper D., Kuhlmann K., Wolf S., Pieper C., Xu G., Ahmad J. (2018). “The future of Battery. Production for Electric Vehicles”, BCG.

Lai I., Liu Y., Sun X., Zhang H., Xu W. (2015). “Factors Influencing the Behavioural Intention towards Full Electric Vehicles: An Empirical Study in Macau”, Sustainability, 7(9), 12564–85.

Marcus, A. A. (2019). “Strategies for Managing Uncertainty: Booms and Busts in the Energy Industry”. Cambridge University Press.

Ministry for the Environment, Government of New Zealand. (2018). “Reducing barriers to Electric Vehicle uptake: Behavioural insights analysis and review”. Wellington: Ministry for the Environment.

Mock, P., & Yang, Z. (2014). “Driving electrification. A global comparison of fiscal incentive policy for electric vehicles”. White Paper. Washington, DC.

Mosquet, X., Zablit, H., Dinger, A., Xu, G., Andersen, M., & Tominaga, K. (2018). “The electric car tipping point”, 6-15, BCG research report.

Musonera, E., & Cagle, C. (2019). “Electric Car Brand Positioning in the Automotive Industry: Recommendations for Sustainable and Innovative Marketing Strategies”. Journal of Strategic Innovation and Sustainability, 14(1).

NUNES, B., & BENNETT, D. (2008). “Environmental Threats and Their Impacts on the Automobile Industry”. International Association for Management of Technology, IAMOT.

Palinski, M. (2017). “A Comparison of Electric Vehicles and Conventional Automobiles: Costs and Quality Perspective”, Yrkeshögskolan Novia.

Ripetskiy A., Mirolyubova T. (2018), “Analysis of factors that determine the possibility for automation of smoothing of product electronic model, obtained through topological optimization for the purpose of its use in the technological preparation of additive manufacturing”, Periodico Tche Quimica, 15(1):405-413

Sang Y, Bekhet HA. (2015). “Exploring factors influencing electric vehicle usage intention: An empirical study in Malaysia”, International Journal of Business and Society, 16(1):57-74

Schoemaker P.(1995) "Scenario planning: a tool for strategic thinking", Sloan Management Review, 36(2), 25-40

Shafiee, S. and Topal, E. (2010). “ An Overview of Global Gold Market and Gold Price Forecasting. Resources Policy”, 35, 178-189.

Situ, L. (2009). “Electric vehicle development: the past, present & future”. International Conference on Power Electronics Systems and Applications, 1-3, IEEE.

Speirs, J., Constestabile, M., Houari, Y., Gross, R. (2014). “The future of lithium availability for electric vehicle batteries”, Renewable and Sustainable Energy Reviews, 35, 183-193.

Stephan B., Lee I., Kim J. (2018) “Crashing the climate. How the car industry is driving the climate crisis”

Stevic, Z. (Ed.). (2012). “New generation of electric vehicles”.

Tang D., Qian, X. (2008). “Product lifecycle management for automotive development focusing on supplier integration”, Computers in industry, 59, 288-95.

Veneri, O., Ferraro, L., Capasso, C., & Iannuzzi, D. (2012). “Charging infrastructures for EV: Overview of technologies and issues”. Electrical Systems for Aircraft, Railway and Ship Propulsion, 1-6.

Xu, G., Li, W., Xu, K., & Song, Z. (2011). “An intelligent regenerative braking strategy for electric vehicles. Energies”, 4(9), 1461-1477.

Yang W., Zhou H., Liu J., Dai S., Ma Z. & Liu Y., (2015) “Market Evolution Modeling for Electric Vehicles based on System Dynamics and Multi-Agents.”, IEEE.

APPENDICES

Appendix 1: Life time vehicle CO2 emissions

PRODUCTION	USAGE	END LIFE
6.8t CO_2	34.5t CO_2	2.7t CO_2
	TOTAL 44t CO_2	

Note: Based on an average volkswagen vehicle

Appendix 2: World fuel price changes 2005-2008, $USD

$ USD	2005	2010	2015	2016	2017	2018
Crude oil	$ 0.34	$ 0.50	$ 0.33	$ 0.27	$ 0.34	$ 0.45
Gasoline (world average)	$ 0.92	$ 0.95	$ 0.84	$ 0.78	$ 0.84	$ 0.94
Diesel (world average)	$ 1.00	$ 1.00	$ 0.92	$ 0.85	$ 0.92	$ 1.05
Δ Crude oil				-18%	26%	32%
Δ Gasoline (world average)				-7%	8%	12%
Δ Diesel (world average)				-8%	8%	14%

Appendix 3: Number of BEV models available in the market per Segment

	now	2020	2021	COMMING SOON
Mini	2	1	0	5
Small	5	6	0	0
medium	6	3	0	0
Large	3	2	0	0
Executive	3	0	1	1
Luxury	0	1	0	4
MPV	4	0	0	0
SUV	11	14	4	2
TOTAL	34	27	5	12

Source: https://ev-database.org/

Appendix 4 : Comparative Analysis: Price per Component BEV vs ICE vehicle

ICE Vehicle components	Component Cost	% of the Total cost	BEV componnets	Component Cost	% of the Total cost
Steering	$ 563	3%	Steering	$ 560	2%
Passenger Restraints	$ 533	2%	Passenger Restraints	$ 535	2%
Exhaust	$ 450	2%	~~Exhaust~~	$ -	0%
Wheels & Tires	$ 405	2%	Wheels & Tires	$ 405	1%
Body Glass	$ 218	1%	Body Glass	$ 220	1%
Interior	$ 1,995	9%	Interior	$ 2,000	6%
Body & Structural	$ 3,795	17%	Body & Structural	$ 4,725	14%
Suspension	$ 750	3%	Suspension	$ 750	2%
Axles, Driveshafs & Components	$ 1,298	6%	Axles, Driveshafs & Components	$ 975	3%
Climate Control & Engine Cooling	$ 1,080	5%	Climate Control & Engine Cooling	$ 1,675	5%
Audio & Telematics	$ 510	2%	Audio & Telematics	$ 775	2%
Fuel System	$ 540	2%	~~Fuel System~~	$ -	0%
Braking	$ 653	3%	Braking	$ 1,240	4%
Transmission	$ 2,085	10%	~~Transmission~~	$ -	0%
Engine	$ 4,013	18%	~~Engine~~	$ -	0%
Eletronics & Eletrical	$ 2,865	13%	Eletronics & Eletrical - Traditional	$ 2,865	9%
GRAND TOTAL COMPONENT COST	$ 21,750		+ EV Eletrical Architecture	$ 1,655	5%
			+ Eletric Motor/Drive/Transmission	$ 1,655	5%
			+ Power Eletronics/ Other	$ 2,105	6%
			+ Battery cell / Pack	$ 11,460	34%
			GRAND TOTAL COMPONENT C	$ 33,600	

Note 1: ICE Vehicle amounts grossed up in line with RPU.
Note 2 : BEV's values based on Chevrolet Bolt and Tesla Model 3.